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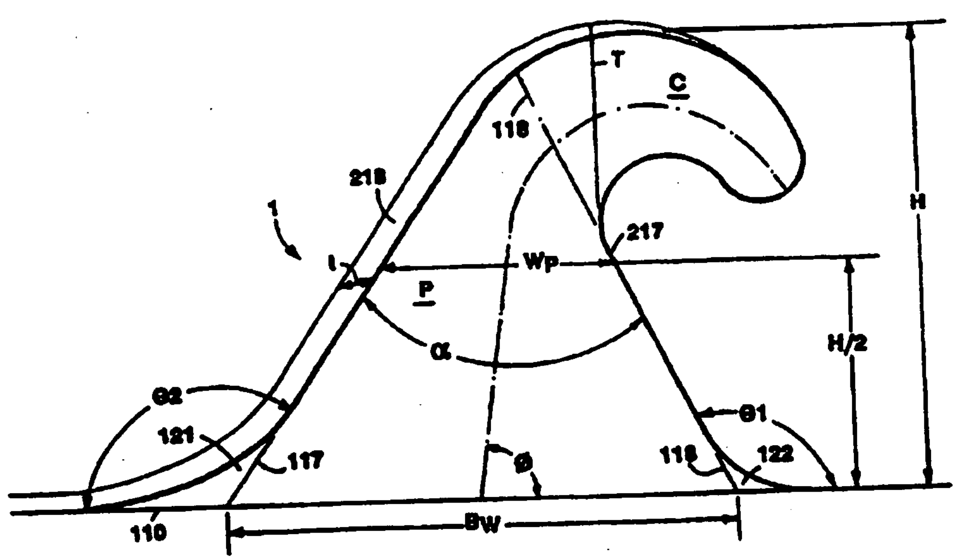

(57) Abstract

A very small, molded, hook-shaped fastener member (12) features an integrally-formed pedestal (13) and crook. In side profile, the pedestal (13) forms a truncated pyramid. Projections of leading (17) and trailing (18) edges of the pedestal intersect near the top of the hook, and at least 40 % of the crook projects laterally from the pedestal. Preferably the fastener member has an overall height of less than about 0.025 inch and a displacement volume of less than about 1.0 x 10^{-6} cubic inches. The mold (80) for forming the fastener member has non-moving mold surfaces that define contiguous pedestal chambers (P) and crook chambers (C). The pedestal chamber is shaped to allow the member to return to its original shape as it is pulled out of cavity (1) before it is completely removed from the cavity. In some embodiments, cut-outs in at least three adjacent plates are aligned to define the mold cavity. Methods of forming the very small mold cavities are also included.

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MOLDED, HOOK-SHAPED FASTENING

Background of the Invention

This invention relates to molding methods and products and to the making of molded hook fasteners for engaging loops.

In the field of molded hook fasteners, typically a series of adjacent rows of hooks forms one side or element of a fastener closure and a mating element provides loops or anchored fibers with which the hooks engage.

A fastener element with rows of hook members is typically formed with a molding tool that has no moving parts. The hooks are pulled from their mold cavities by distorting the hooks. For molding continuous strips of such hook members a rotating mold roll is employed, while for discrete items injection molding techniques are employed. Improvements applicable to such molds and to the processes of molding these hook members may be useful in molding other products.

Summary of the Invention

It is realized that molded fastener hooks with very small hooks (e.g., of height less than about 0.025 inch) can provide better engagement with low-lying loops or fibers of inexpensive fabrics because the probability is increased that each hook of a fastener will engage a loop or fiber.

There are a number of seemingly conflicting considerations that stand in the way of realizing this objective in a manner that provides highly effective fastening. As the hook members become smaller and thinner, they become more flexible. This increases the tendency for hooks under slight load to disengage from the mating fabric. It is usually important that such

small hook members present a significant re-entrant crook, i.e., a hook tip that tilts downwardly, in order to better snag and retain the loops or fibers of the mating fabric. It also is important that the crook of the hook have a very low displacement volume to enable sufficient penetration into low loft fabrics to enable loop or fiber engagement. Crook displacement volumes, as defined below, of less than 1.0×10^{-6} cubic inch and preferably about 0.5×10^{-6} cubic inch or less are desired. It is of course also important that the peel and shear strengths of the overall fastener meet the strength demands of the conditions of use. Consequently, the hooks and the loops must have sufficient strength to maintain engagement but also sufficient flexibility to disengage without destroying the hooks or the loops.

The preferred known technique for making high performance hooks has been to employ molds that have no moving parts, but hooks of the size of interest here are especially difficult to achieve by such conventional techniques.

The present invention provides improved molds and techniques for making the hooks and other products, improved techniques for making the molds, and improved products.

According to one aspect of the invention we have realized that effective molded hook members of height less than 0.020 inch, that have efficient loop or fiber engaging crooks and displacement volumes of less than 1.0×10^{-6} cubic inch and preferably about 0.5×10^{-6} cubic inch or less (such hooks are sometimes referred to herein as microhooks), can be reliably produced at high speed and low cost by use of special shape parameters for the mold cavity in which the hook is formed.

A conventional mold cavity defines a hook profile consisting of a relatively short base or pedestal, a

relatively elongated stem section, and a crook or return section. We have realized that an effective microhook can instead be formed by use of a mold cavity profile that is defined essentially by a pedestal portion to which a tapered crook portion is directly joined.

In a preferred microhook mold cavity, the base width and taper rate are also important. Preferably, the base is at least about 100% of the overall hook height, more preferably at least about 110% or more. Preferably, the taper (rate of change of width relative to distance along the hook axis) of the hook cavity from its base at least to a level of half of the height of the hook cavity is greater than 0.6 to 1, more preferably greater than 0.8 to 1 and most preferably greater than 1.0 to 1.0.

In preferred profiles of this kind, the pedestal cavity has a much larger taper from its base to the midsection of the hook than the taper of the crook section. A pedestal taper of more than four times and preferably more than five times the taper of the crook portion is employed. In preferred implementations, the sides of the profile of the mold cavity are straight and a projection of the converging sides intersect at an apex angle of 40° or more, preferably, at least 50° and in the presently preferred implementation, 60°.

Such mold constructions produce hooks that are strong for their size and enable a high density of the hooks to be achieved.

Such mold constructions also enable the molded crook portion of the hook, after undergoing deformation during withdrawal from the fixed mold cavity, to be rapidly exposed to an expansion space that quickly gives room for the crook portion to recover toward its originally molded form.

By use of these novel mold cavity parameters, we realize that certain conditions in th molding of

microhooks can be overcome. Immediately upon molding in a cooled mold, a hook has a memory for its initial molded condition. After being deformed the crook tends to return to the initial form. However, if a hook member has a significant crook, it cannot be withdrawn from a fixed mold unless it remains warm and readily deformable. To the extent the hook member cools while being withdrawn, a tendency is introduced for the hook to set in the deformed condition, and not return sufficiently to the designed crook shape.

These factors have been present in the molding of hook members of larger form, but have not appeared critical. We realize, however, that with microhooks, these factors can be more critical: because the very small crook tips have a significantly increased ratio of exposed cooling surface relative to mass, the fabric-engaging crooks tend to cool and set more quickly than do molded hook elements of the conventional larger form. With the novel mold cavity parameters provided by the present invention, the degree of setting in deformed state can be decreased because the relative duration of exposure of the hook member to the deformed condition is decreased. This enables effective production of microhooks having a high level of performance. We have realized that products made with the mold profile and techniques just described have other advantages, even where rapid recovery of the hook tip shape is not important. The wide based pedestal to which the crook is directly attached provides a profile with considerable strength in shear loading. Accordingly, the cross-row thickness of the hook can be less than the conventional thickness of 0.008 inch or more; preferably the hook has a thickness of 0.006 inch or less. Likewise the spacing between adjacent rows of hooks can be less than about 0.010 inch, preferably about 0.008 inch or less. Density

of distribution of the hooks in the direction cross-wise to the direction of the rows of hooks of about 50 per inch or more can be advantageously achieved, preferably about 70 hooks per inch or more.

The smallness of the hooks also enables densities of distribution in the direction of the rows of hooks of about 20 hooks per inch or more, preferably about 25 hooks or more per inch.

In particular it becomes possible to mold highly effective hook members that have an areal density greater than 1000 hooks per square inch, and preferably greater than 1500 hooks per square inch. Hook members of such areal density and form have been found to have an aggregate strength effect that can meet the strength demands of many conditions of use, while providing a hook surface that is soft to the touch due to the aggregate surface effect provided by the closely adjacent hooks. The preferred downward orientation of the tips add to this effect. Each of these features makes the hook member useful on items that lie close to the skin.

When the molds are provided on a rotating molding roll, the mold profile of the invention enables particularly efficient production of running lengths of many closely spaced rows of high performance hook member. The invention is also useful for fixed molds for use in injection molding. Microhooks molds can advantageously be formed by use of photochemical milling techniques, which have unique advantages to the formation of molds for microhooks. They enable the production of hooks that are extremely small (less than 0.010 inch in height), so small that we term them "sub-microhooks". Furthermore, these techniques provide very smooth surfaces for the mold cavities. These have special usefulness to produce hooks for use with extremely low loft materials. In certain circumstances laser machining, EDM and plating

techniques can also be employed to form the molds for the unique products of the invention.

The fastener members of the invention can also be advantageously oriented at various angles to the machine direction of a mold roll, or of molds formed by face-to-face assembly of the molding plates, by aligning cut-outs or apertures in a number of adjacent plates to define the mold cavity.

According to one aspect of the invention, a mold for integrally forming from a moldable resin a large multiplicity of hook-shaped members on a sheet or strip-form base is provided. The mold has hook-shaped cavities located at the surface of the mold, at least many of the hook-shaped cavities having a tapered pedestal chamber and a crook chamber which are contiguous.

In preferred embodiments, the pedestal chamber has a base width greater than about the height of the hook-shaped cavity and at half height of the hook-shaped cavity, has a width equal to about half the height of the hook-shaped cavity or more.

An important feature of the invention is that lower portions of the pedestal chamber are substantially wider than the crook chamber, such that space is provided for a formed hook member to substantially recover the shape of the cavity before it is completely removed from the cavity.

In particular implementations, at least many of the hook-shaped cavities have a height less than about 0.015 inch, more preferably less than about 0.010 inch.

In certain embodiments, the mold is combined, at a molding station, with an extruder in the vicinity of the mold cavities for delivering molten resin to the cavities.

In some cases, means are included for applying pressure to the molten resin for promoting filling of the

mold cavities. In some instances where the mold is a mold roll, the means for applying pressure includes a pressure roll. In other instances where the mold is a mold roll, the means for applying pressure includes a nozzle surface closely fitted to the roll for confining molten resin under pressure.

In some embodiments, at least some adjacent plates are laminated.

Preferably, the hook-shaped cavity is of form produced by photochemical machining.

In some key embodiments, the crook chamber of the hook-shaped cavity is set at an angle with respect to the plates. In other instances, the crook chamber is perpendicular to the plates.

For some applications, the hook-shaped cavities are arranged in a helical pattern about the mold roll.

According to another aspect of the invention, a molded hook fastener member of a hook and loop touch fastener is formed by the process of delivering a moldable, heated material to a mold according to the methods described above.

In some embodiments, the molded hook fastener member is molded in a single hook cavity formed by aligned cut-outs in at least three adjacent plates. Preferably, the cavity is defined by photochemically milled plates.

Preferably, the molded hook members have a height less than about 0.020 inch, a thickness of about 0.006 inch or less and are disposed on a sheet-form base at a density of at least 1200 molded hook members per square inch.

In some preferred embodiments, the molded hook member has a displacement volume of less than about 0.5 x 10^{-6} cubic inches.

Brief Description of the Drawing

Figs. 1 and 1A are side views of a mold cavity;

Figs. 2 and 3 are side and top views, respectively, of a hook component.

Figs. 2A, 2B, 2C and 2D are side, end, top and perspective views, respectively, of a hook member.

Fig. 4 is a schematic view of a system of forming hook members using a mold roll and a pressure roll. Fig. 4D is a schematic view of a system of forming hook members using a mold roll and an extrusion head.

Fig. 4A is a perspective view of a mold roll, in isolation. Fig. 4B is a close-up, section view of the surface of the mold roll. Fig. 4C is a perspective view of an injection mold showing the orientation of a mold cavity diagrammatically.

Figs. 5A and 5B are a series of side views showing a hook member being removed from a mold cavity in a mold roll, against and in the machine direction, respectively.

Fig. 6 is a cut-away view of a mold cavity formed by several adjacent plates.

Figs. 7A-7K are side views of sections of the plates in Fig. 6, shown diagrammatically.

Figs. 8A and 8B are side views of sections of the plates in Fig. 6, shown diagrammatically, in which the cut-outs have curved sides and a wedge is formed at the top of the cavity.

Figs. 9A and 9B are side and end views, respectively, of a hook member having a wedge at the top.

Fig. 10A is a side view of a hook member having a curved side. Figs. 10B and 10C are cross-sectional views of the hook member shown in Fig. 10A.

Figs. 11A and 11B are diagrammatic, perspective views of the surface of a section of a mold roll depicting mold cavities having various orientations with respect to machine direction.

Fig. 12 is an end view of a hook member having a taper running 90° to the profile direction.

Fig. 13 is a prospective view of a hook member having a circular cross-section. Figs. 13A and 13B are cross-sectional views of the hook member shown in Fig. 13.

Fig. 14 is a plan view of a mold cavity used to form the hook member of Fig. 13.

Figs. 15 and 16 are diagrammatic views of a mold cavity, and a mask used to form the mold cavity by photochemical milling. Fig. 15A is a cross-sectional view of a cavity formed by photochemical milling.

Fig. 17A is a side view of a microhook. Fig. 17B is a side view of a sub-microhook. Fig. 17C is a side view of a sub-microhook in which the crook extends essentially horizontally.

Implementations

Referring to Figs. 1 and 1A, the profile of the mold cavity 1 of a preferred implementation of the invention is shown. It defines a pedestal portion or chamber P and a crook portion or chamber C. The pedestal portion has the profile of a broad based triangle, with its relatively straight sides projected to intersect at apex α in the vicinity of the top of the mold cavity. The mold cavity has a total height H and a half height of H/2.

The mold cavity profile has a base width B_w, measured between intersections of projections 117 and 118 of the sides of the mold cavity with the base surface 110 of the mold, that is greater than about the height H of the hook element; as shown, B_w is about 110% of the height.

At half height (H/2) of the mold cavity, the pedestal portion has a width W_p about equal to the half height of the hook.

With an apex angle α of about 60°, the pedestal portion continuously tapers from the base (ignoring front and back fillets 121 and 122) at a taper rate of about 1.2 to a point above the half height. The inside surface 217 of the mold cavity then begins to curve to define the lower surface of the crook portion, while the back surface 218 of the mold cavity profile proceeds straight for a further distance. The pedestal portion is considered to end where a tangent T to the inside surface 217 is vertical. Referring to Fig. 1a, the pedestal height H_p is greater than the half height of the hook member.

The crook portion of the mold cavity tapers continually to its tip, though at a much lesser rate than the general taper of the pedestal. In the profile of Fig. 1A, the crook portion continues until its tip portion, directed downwardly, reaches the level of the top of the pedestal portion.

A hook component 100 of a touch fastener in accordance with a preferred implementation of the invention is shown in Figs. 2, 2A, 2B, 2C, 2D and 3. The hook component consists of a sheet form base 10 and multiple parallel rows of integrally molded hook members 12 extending from the base sheet. Ripstop bumps (not shown), i.e., known raised local regions of the base in the spaces between rows of hooks, may be employed either aligned with the hook members or offset from the hook members, depending upon the intended application.

Corresponding terms will be used to describe features of a hook member produced from the mold cavity. A broad-based, tapered pedestal 13 of the hook member is integrally formed with and extends upwardly from the base

10. The pedestal has a straight sided, pyramidal shape when viewed in side profile (see Fig. 2A). A tapered crook portion 14 is integrally formed with the pedestal. The crook portion arches along a curved axis 15 directly from the top of the pedestal to a tip 16. The tip is adapted to engage a mating fabric.

The width of the crook portion, measured perpendicular to its curved axis (e.g., dimension D of Fig. 2A), continuously decreases from the pedestal to the tip.

The leading and trailing surfaces 17, 18 of the pedestal form angles θ_1 and θ_2 relative to the sheet-form base, respectively, that are substantially greater than ninety degrees. Preferably, θ_1 and θ_2 are between about 110 and 130 degrees. More preferably, θ_1 and θ_2 are about 116 degrees and 125 degrees, respectively. Preferably, when the leading edge and the trailing edge of the hook profile are projected, they intersect at an angle α of at least about 40°, more preferably about 50°, and most preferably about 60° or more. The axis 15 intersects the base at an angle ϕ that is preferably greater than 80° and more preferably approximating 90°. Forming the pedestal as a truncated, broad-based pyramid when viewed in side profile, such that the edges slant inward toward each other, allows the hook members to be removed more easily from the mold cavity 1 because the crook portion 14 can pass more easily through the portion of the mold cavity in which the pedestal was formed (i.e., through the pedestal chamber). Furthermore, due to the relatively wide pedestal base width, each hook member is able to withstand relatively high shear loads despite the relative thinness of the hook member, which enables higher cross-row densities of the hook members to be achieved. Furthermore, the relatively wide pedestal

allows the hook member to better resist bending, thereby maintaining a better grip on the loops.

For use in some important applications in conjunction with non-woven loop members (which may be only 0.001 inch in diameter and 0.0005 to 0.0020 inch tall), the hook members are generally quite small. Height 130 of hook members 12 is preferably less than about 0.020 inch, with 0.0150 inch or less being preferred for microhooks. Furthermore, the pedestal base width 19 for hooks of about 0.015 inch height (i.e., the width of the pedestal, taken parallel to base 10 at the level where the pedestal joins the base, disregarding fillets 21 and 22) is preferably between about 0.010 inch and about 0.025 inch, with about 0.0170 inch presently being most preferred.

Referring to Fig. 2D, the hook member has a displacement volume defined by a parallelepiped 110 having a bottom plane 101, first and second side planes 102, first and second end planes 103, 104 and a top plane 106. The bottom plane is oriented parallel to the base and tangent to the tip. The top is parallel to the base and tangent to the top of the hook member at the point where the hook member achieves its maximum distance from the base. The side planes lie in the planes of the sides of the hook. The first end plane 104 is perpendicular to the bottom plane at the point where the bottom plane intersects the hook member at its trailing edge 18. The second end plane 103 is perpendicular to the bottom plane and tangent to the outermost portion of the crook. The mold cavity has a crook height H_c, a crook width W_c and a thickness, t. The displacement volume DV of the crook portion of the hook member formed in the mold cavity is calculated as $DV = W_c \times H_c \times t$. The hook member has a displacement volume of less than 1.0×10^{-6} inch^3 and preferably about 0.5×10^{-6} inch^3 or less.

Referring to Fig. 1A, the crook projection, i.e. the distance the crook portion projects laterally from the top of the pedestal is shown as W_1, which is greater than 40% of the crook width W_c.

This profile also satisfies the preferred constraint that the height P_1 of the pedestal, at which the pedestal width W_p is equal to the width W_c of the crook portion, is at a height greater than 30% of the height H_p of the pedestal.

Numerous advantageous implementations of the profile can be employed to realize microhooks of height less than 0.020 inch and displacement volume less than 0.5×10^{-6} inch^3. In one specific implementation, a hook member having an overall height H of 0.015 inch is provided. The width W_c of crook portion is 0.013 inch, the height H_c is 0.005 inch, the thickness, t, is 0.006 inch and the displacement volume is 0.4×10^{-6} inch^3.

The fastener element 100 or hook strip, including the hook members, is advantageously formed using the Fischer process, U.S. Patent 4,794,028, fully incorporated herein by reference, in which the mold cavities for rows of hook members are formed in the peripheries of corresponding disk-form mold plates, the plates being stacked alternately with spacer plates that form the flat sides of the hook members, with strengthening formations of bumps formed in the spacer plates that can add strength to the hook strip. In a preferred implementation as shown in Fig. 3, in the machine direction (i.e., the direction in which the strip being formed travels) there are preferably about 24 hook members per lineal inch. The hook members preferably are spaced apart laterally (i.e., in the cross machine direction) a distance 23 of about 0.008 inch, and the pedestals 13 preferably have a thickness 24 of about 0.006 lineal inch. This yields a density in the cross

machine direction of approximately 71 fastener elements per inch. Hence, there are preferably on the order of 1700 hook members per square inch.

As shown in Fig. 4, a preferred method for making such molded hook members entails extruding molten resin into the nip formed between a cooled mold roll 80 and a pressure-applying roll 82. The cooled mold roll has mold cavities 1 about its periphery that are configured to produce hook members. A backing sheet 201, such as a woven or non-woven fabric, may be supplied from a backing sheet roll 200 to the nip. This backing sheet may contain loops adapted to engage the hook members. The resulting fastener element will then include hook members bound to the backing sheet in what may be termed an in situ laminating process, producing a laminated (i.e., bonded together) hook product. As an alternative to using a pressure roll, Fig. 4D shows an extrusion head F for presenting resin to the surface of the mold roll 80 under pressure. Head F has a contoured surface 480 that is spaced apart from the surface of the roll to form the base of the hook product.

Referring to Figs. 4A and 4B, the mold roll comprises a series of disc-form plates or rings 250 mounted upon a cooled central barrel 251. The rings are pressed together axially to form a cylindrical surface. Spacer rings are disposed between the tool rings. The mold cavities are disposed at the periphery of the tool rings between the spacer rings. The mold cavities, and any bump or other formation cavities in the spacer ring, are provided in a predetermined relationship to provide hook members on the base in a desired relationship, as the particular application requires. As shown, the mold roll is comprised of rings. However, circular plates, having molds at their periphery and cooling chambers running through the plates, can also be employed.

Because the hook members face in opposite directions, the hook members in half of the columns are oriented along the direction of travel of the fastener element, and the hook members in the other half of the columns are oriented opposite to the direction of travel of the fastener element. As shown in Fig. 5A, a sequence showing the removal of a hook member 12 from a mold cavity 1, the hook members that are oriented against the direction of travel can leave the mold cavities of the mold roll without significant bending. However, as shown in Fig. 5B, the hook members that are oriented along the direction of travel must bend around the edges of the mold cavities as they are extracted from the cavities. This deforms them slightly, causing them to extend higher from the base sheet and at a slightly steeper angle than the hook members that are oriented against the direction of travel. Due to the very small size of the hook members, there has been a tendency for the prior art hook members to cool and set in the deformed condition. The hook-shaped cavity disclosed, however, provides ample space for the crook to return to the shape of the cavity before the hook member is completely withdrawn from the cavity, thereby reducing the tendency of the hook to set in the deformed condition.

Furthermore, for making the two sets of hook members even more uniform, the hook members may be passed under a knock-down roller 86, the spacing of which, relative to wrap-around roller 87, is adjustable. The knock-down roller may be employed to push any higher or steeper hook members back to the same level, relative to the sheet form base, as the level of the hook members that are oriented in the opposite direction. The knock-down roller 86 is located close to the position where the hook members are withdrawn from the cavities so that the hook members ar still slightly soft and permanently

deformable when they pass under th knock-down roller and thus retain their new shape.

The mold cavities 1 are shown disposed at the periphery of the mold roll 80 and the moldable resin is delivered to the surface of the mold roll at a nip. It will be appreciated that the moldable resin can be delivered to the mold cavities in numerous ways. For example, the moldable resin can be delivered to the mold roll directly from an extruder. After traveling along the surface of the mold roll, the resin is then pressed into the mold cavities using a pressure roller. In other cases, the extruder is mounted to extrude with pressure against the roll surface, with extensions of the nozzle surface that conform to the roll serving to keep the extruded resin at sufficient pressure to cause the mold cavities to fill with resin.

Other methods for delivering moldable resin to the mold cavities can also be employed. For example, referring to Fig. 4C which is a perspective view of an injection mold showing the orientation of a mold cavity schematically, the moldable resin is injected into the mold cavities 1 which are situated on an injection mold 150, thereby forming the fastener elements by injection molding. The injection mold is formed of a series of plates 151 disposed face-to-face to create a flat (or curved) surface having mold cavities. The mold cavities can be formed in one or more plates. After molding, the overall mold opens, the hooks are withdrawn from the mold cavities as the molded piece is removed, and the overall mold closes for another injection cycle. Injection molding can be employed to form the hook members directly on a rigid backing which, in turn, can be attached to a separate part. Injection molding can also be employed to form the hook members integrally with a part, such that

the hook members do not need to be later attached to the part.

The moldable resin may be any plastic material depending on the intended application for the fastener element. Currently, polypropylene is preferred. Nylon, polyesters, polyethylene, propylene, ethylene and copolymers thereof, or other thermoplastic resins, may also be readily employed.

Other important aspects of the invention concern the making of products that employ three or more mold plates that define the mold cavities. This technique is especially useful in forming hooks by the roll molding process that have a cross machine orientation, or in forming hooks that extend cross-wise to the planes of assembled plates in a stationary mold. These plates are preferably formed by specialized photochemical milling techniques. Alternatively, EDM techniques, laser milling or other techniques can also be employed to form the plates.

For example, Fig. 6 is a cut-away view of a mold roll through a radial plane 6-6 of Fig. 4A. Photochemical milling technology or other high accuracy forming techniques, such as laser milling, are employed to form mold cavities that extend in the cross machine direction of the mold roll. As shown, the mold cavity is hook-shaped. However, other shapes can be employed, if it is desired to form other fastener products, or even to form elements that perform other functions.

In Fig. 6, the mold cavity is formed by a plurality of stacked disk-form plates which are assembled face-to-face on the roll axis, thereby defining surface 110 of the mold roll. Each successive plate has material removed a different amount, according to slices taken of the profile of the desired mold cavity, so that only a portion of th cavity is formed in each plate. Typically

part of the cavity is formed by a through aperture in one plate, while plates on each side of that plate have cavity portions in at least part of the thickness of the plate.

As shown in Fig. 6, the plates all have the same thickness. According to the invention, however, in certain advantageous implementations the plates have differing thicknesses, based on the intended application of the hook, the desired profile, or the density of the feature formed. In certain applications, the use of plates of differing thickness enables more economical fabrication since fewer plates are required to form the mold cavity. Further, the use of plates of varying thickness in other instances enables efficient definition of the mold shape, or the achievement of curved surfaces of exceedingly small radii and/or smoother transition. In important cases, as the radius of curvature of a feature becomes smaller, thinner plates are employed for better definition of the surface.

The plates may be only 0.003 or 0.004 inch thick or less when forming small hooks. According to the invention, to enable use of very thin plates for forming special features, prior to assembling to form either a stationary mold or roll mold, one or more of the thin and delicate plates are laminated together to create a more rugged master plate that can be readily assembled on the cooled barrel without risk of distortion. The plates may be laminated (i.e., bonded together) by brazing, high temperature, long life bonding agents, or other means.

Returning to Fig. 6, in plate h, for example, the cavity section extends through the entire thickness of the plate in areas 308 and 309. In plate k, the cavity section extends through only a portion 314 of the thickness of the plate, to define the tip of the mold cavity.

In this approach, usually each plate is different from its neighbor and only by the stacking of the plates together is the mold cavity formed. In this way, hook members in the cross plate direction may be produced (cross-machine direction in the case of roll molding).

One can produce by this technique hook members that have flat surfaces. Advantageously, however, hook members are produced that have rounded surfaces in some or all regions, from base to tip. For instance, surfaces at the tops of the hook tips are made to taper to a point to give a wedge-shaped effect to the top of the hook member that assists the entry of the top into the face of a mating fabric.

Figs. 7A-7K show, in diagrammatic form, a series of cut-away sections of rings that correspond with rings a through k of Fig. 6. Ring a has a small section 300 of the outer edge removed, representing a section of the backside of hook 400. The next ring, b, has a cavity section 301 that forms the next section of the backside of the hook. The cavities through ring h become successively taller to form corresponding sections of the backside of the hook.

In ring h, cavity section 308 forms a section of the pedestal of the hook that is diminished in height, representing the transition toward the other side of the hook. Cavity section 309 forms the beginning of the top of the crook. In the next ring, i, cavity section 310 is diminished to represent the pedestal becoming shorter, while cavity section 311 forms the part of the crook that progresses downward. At ring j, cavity section 312 is the last section of the pedestal, and cavity section 313 approaches the tip of the crook. Finally, in ring k, cavity section 314 forms the actual tip of the hook. Since there is no portion of the pedestal formed by ring k, there is only one cavity section in this plate.

The techniques described enable one to optimize the shape of the selected areas, especially in sections h, i, j and k. Figs. 8A and 8B thus show an alternate way of creating a mold cavity that, according to a further aspect of the invention, is achieved by photochemical milling. Cavity sections 300-314 in Fig. 7 have straight sides which produce a hook member with flat sides; as a result of the inherent tendency of photochemical milling to form curved surfaces, a hook member (as in Figs. 8A and 8B) is created that has curved sides rather than flat sides. As the crook is approached in plate H′, cavity section 309′ not only has curved sides, but has a point to produce a crook of wedge form at its top.

Figs. 9A and 9B show a hook in which the top of the crook is wedge shaped, created by cavity section 309′ such as is illustrated in Fig. 8B. The top of the hook member thus has a two-sided wedge effect to separate the fibers or the filaments of the mating fabric and allow the hook member to penetrate the surface and subsequently engage better into the loops or with the fibers.

Figs 10A, 10B and 10C show a hook member which is formed by milling the hook shape by photochemical milling techniques into one ring, and defining the cavity with the milled ring and a flat ring. The hook member is curved on one side and flat on the other. Consequently, a one-sided wedge is formed at the top of the hook member to better penetrate loops.

The techniques just described, of creating curved surfaces to the hooks to form top wedges or smooth non-abrading surfaces, are applicable to formation of hooks that extend, as desired, in either the direction of the plate (machine direction for roll molds) or across the plate (cross-machine direction for roll molds).

An advantage of making hook members in the manner just described, in which the hook member is aligned in the cross machine direction of the mold roll, concerns the manufacture of apparel. A tape of conventional hook form is often employed in an orientation that does not point the hooks in the optimum orientation. Molding hooks in a cross machine direction, for such cases, enables the points of the hooks on the tape to be directed to optimize the engagement into the loops or with the fibers.

The sectioned technique described with respect to Figs. 6-8 advantageously enables hooks of different size and shape to be created which vary along the length of the product to accommodate the conditions of various uses of the fastener. Advantageously, the hook sizes and shapes are likewise varied around the circumference of the tooling as suggested in Fig. 10. Likewise, in certain advantageous circumstances, the sizes of the hooks are varied in the machine direction. Thus one achieves hooks of different sizes extending in both directions, interspersed with each other, according to a predetermined pattern. In certain implementations, adjacent hooks lie at 90 degrees to each other in a repetitive pattern in both directions. Also, according to predetermined patterns, machine direction hooks are alternated with cross machine direction hooks to reduce the sensitivity of the product to orientation.

Using the techniques just described, the invention also enables hooks to run at an angle relative to the cross machine and machine direction, i.e., in a helical or biased configuration, such that components of the projection of the hook member extend in both the cross machine direction and the machine direction. For instance, in certain embodiments, rings are formed such that the hooks extend at an angle of 45 degrees to the

machine direction. Figs. 11A and 11B, which are perspective views of a section of the surface of a mold roll showing the location and orientation of mold cavities, schematically illustrate these various orientations. Similar orientations (e.g., with-the-plate and across-the-plates orientations) are also achieved for fixed molds.

The present techniques therefore enable practical manufacture of hooks (including hooks with multiple crooks) having various orientations and patterns relative to the machine direction of the mold roll. Palm tree hooks (hooks having two tips), trident hooks (hooks with three tips) and quadra hooks (four-tip hooks) are made feasible by the techniques described herein.

The molding action of the hook shown in Fig. 6 will now be described. In Fig. 6, the same profile that has previously been described in Fig. 1 is shown, rotated 90 degrees relative to the machine direction.

The pedestal base is wide, allowing the hook to demold and spring back to its original shape before it clears the pedestal cavity in order to reduce distortion, as described above. A further feature of the design is that a wide pedestal also is provided in the machine direction. This effectively produces a pedestal that is broad both in the crook direction and at 90 degrees to the crook direction, effectively forming a true pyramid pedestal that tapers inwardly on all four sides.

Fig. 12 is the end view of a hook member mold employing the section cavities of Fig. 8, but having tapers running 90 degrees to the profile direction (i.e., in end view). In certain advantageous instances, the taper rate is 0.6 to 1 up to 0.8 to 1 or more. In certain advantageous instances, the taper in end view matches the taper in side profile, about 1.2 to 1. This provides a very substantial ped stal which enables the

hook member to perform well because it is sturdy and well anchored. Of course, other profiles are made possible by the invention.

The taper shown in Fig. 12 also enables the hooks to be readily demolded. According to the invention, tapers of the pedestal are selectable that simultaneously enable demolding of cross machine hooks, provide a large pedestal cavity for the crook of the hook member to snap back to molded shape as demolding progresses, and provide hooks that are very strong relative to their small overall height.

In addition to enabling production of a pedestal with tapers in both machine and cross machine directions, the techniques are employed to introduce curved surfaces and to create a molded pedestal that is of cone shape as shown in Figs. 13, 13A, 13B and 14. The conical shape provides a sturdy hook, but with smooth surfaces that in important instances enable the avoidance of abrasion that sharp corners or flat surfaces can produce.

Rounded surfaces of the hook members also in certain circumstances reduce the chance of fatigue fracture as compared to sharp corners. Without sharp corners, such hooks may return to their original shape during disengagement because they do not so readily suffer fatigue. Also such rounded hooks are capable of an increased number of cycles of fastening and unfastening before failure.

Special photochemical milling techniques have novel use in forming the numerous microhooks described above (or submicrohooks to now be described) of conventional and cross-machine orientation.

In the making of a mold for the hook profile shown in Fig. 6, according to this aspect of the invention, photochemical milling techniques are employed. For a given plate, a piece of flat sheet stock is s lected from

which the mold cavity or cavity section is to be formed. In the case of a mold roll, the sheet stock is sized to form a component disk of the mold roll. The material may be 17-7 PH stainless steel or other suitable metal. A photosensitive media, i.e. a photoresist material, is applied over the plate and is exposed to a radiation (e.g., light) source through a compensating mask so that the photoresist will be removed where it is desired to remove metal to form the mold cavity. The mask blocks a predetermined portion of the light so that the photoresist material is exposed to a predetermined pattern of light. The mask is positioned between the light source and the photoresist material. In particular, the mask may be applied directly to the photoresist material.

Currently, the photoresist material is preferably a positive photoresist material. When exposed to the light, the positive photoresist material cures onto the plate. The remaining portion of the photoresist material which was not exposed to the light is then removed. Alternatively, a negative photoresist material may be employed. When exposed to the light, the negative photoresist material is the portion that is removed. The remaining portion of the photoresist material which was not exposed to the light remains on the plate.

In Fig. 15, the mask is shown in dashed lines, superposed over the profile of the desired hook shaped cavity, shown in solid lines. The portion of the photoresist that is to be removed is within the dashed lines. After the photoresist is exposed to the light, the photoresist is washed away to expose the pattern of the art work. Then the metal sheet is placed in a machine, and the metal not covered by the photoresist material is removed by action of etchant. A spray of tchant (e.g., acid) is employed, as is conventional in

photochemical milling. After milling, the portion of the metal plate covered by the photoresist layer remains.

With respect to Fig. 15, regions A-G designate different portions of the shape of the cavity and, diagrammatically, of the compensating mask. In some regions, the dashed line of the compensating mask and the edge of the desired cavity generally correspond, while in other regions they do not.

For straight line regions (e.g., region B in Fig. 15), the edge of the compensating mask generally corresponds to the straight line of the cavity profile that is desired (the shallower the mill depth, the closer the correspondence). However, in curved regions the lines of the mask diverge more substantially from the desired profile. The more radical the curvature is, the greater is the difference between the mask and the desired profile. In areas where the curve of the desired cavity edge is convex, the compensation is to opposite effect to the compensation where the curvature is concave. In general, for etching convex edges, such as at A, the mask is compensated to be undersized with respect to the cavity because the action of the etchant will be relatively concentrated for a given length of cavity perimeter, relative to a straight edge. For concave edges, such as at C, the art work of the mask is enlarged to compensate in the opposite way. At region E in Fig. 15 the surface is even more convex than in region A (i.e. it has a smaller radius), and therefore the compensation is greater, providing more undersizing of the cavity defined by the mask.

The art work of the compensating mask defines points in the regions D and E. The tendency in photochemical milling is for sharp corners to be rounded. In this case, since a small rounded tip shape is desired, the compensated art work comes to a sharp point. Region

F is a straight line, similar to region B, and region G corresponds to region A. Thus the art work profile for all regions of curvature of the hook is, in this example, different from the profile of the final hook cavity.

Fig. 15A shows a cross section of the metal after action of the etchant in which advantage is taken of the tendency in the photomilling process to produce a curved rather than a straight surface. This is found to generate a desirable rounded shape, particularly at the edge of the top of the hook. The rounded shape provides a surface that can more readily penetrate the surface of a mating fabric than a flat surface. Further, in important instances, the naturally rounded shape of the surface of the milled plate is exploited to create a smooth curve extending across several adjacent plates.

Selection of the particular compensating techniques for the art work, the photoresist materials, and the etchant depends upon the particular metal being exposed, the depth of metal removal and other conditions, as is well known in the art of photochemical machining. For specific process details, see the technical paper published in 1976 by the Society of Manufacturing Engineers, entitled "Photo-Chemical Machining Fundamentals With Three Unique Applications" by Dr. R.J. Bennett; Photo Chemical Machine Institute publication no. PCMI1000, entitled "What is Photo Chemical Machining Process and What Can It Do For You?"; conference proceedings of The Society of Carbide and Tool Engineers cosponsored by Medicut Research Associates, Inc. and the Abrasive Engineering Society, entitled "Nontraditional Machining Conference Proceedings of the Conference Held December 2 and 3, 1985"; and to the references cited in those papers. The specifically cited papers are hereby incorporated by reference.

Fig. 16 illustrates an alternative compensating mask in which the straight lines and sharp corners are used to provide smooth, small radius surfaces in the produced part. The art work is shaped as small squares near the tip of the hook where a smooth radius of one curvature transitions into a smooth radius of the opposite curvature.

Various techniques are employed to obtain different desired profiles on the plates. For example, in producing cavities or cavity sections that extend through the plates, the plates are advantageously photochemically milled from both sides, thereby reducing the total concavity of the milled surface, and, in certain circumstances where desired, providing an overall convex surface. In certain advantageous instances, the sides of the plate are exposed to the etchant for different amounts of time, creating different shapes at opposite sides of the plate. The etchant liquid is either sprayed at the surfaces to be etched, or directed in a stream to increase its local effectiveness.

Referring to Fig. 17B, a hook element according to Figs. 2A-2D has an overall height H of 0.008 inch. The radius of the tip surface is approximately 0.0008 inch. This hook is shown in Fig. 17A next to a microhook having height H of 0.015 inch, described earlier, for comparison. Because it is has a height less than 0.010 inch, we refer to the hook of Fig. 17B as a "sub-microhook". It has been advantageously formed in different instances by photochemical milling into the side of a plate to a depth of 0.003 inch and 0.005 inch. The hook element of Fig. 17C is of similar configuration except that the projection of the crook is not as great, and the top of the crook extends essentially horizontally. This profile represents a different trade-off with respect to displacement volume and hook shape

that is appropriate in certain circumstances. The displacement volume of the hook member of Fig. 17C is less than that of Fig. 17B because it omits the downward projection of the tip. This form of hook is considered to be useful, for instance, with nonwoven fabrics in which the fibers are tightly bound to the material and present little loft. When employed in close association with rows of hook elements pointing in the opposite direction, the hooks of Fig. 17C provide effective engagement in certain instances.

Other embodiments are within the scope of the following claims.

What is claimed is:

1. A mold for integrally forming from a moldable resin a large multiplicity of hook-shaped members on a sheet or strip-form base, the mold having hook-shaped cavities (1) located at the surface of the mold, at least many of the hook-shaped cavities having a tapered pedestal chamber (P) and a crook chamber (C) which are contiguous.

2. The mold of claim 1 wherein the pedestal chamber (P) has a base width (B_w) greater than about the height (H) of the hook-shaped cavity and at half height (H/2) of the hook-shaped cavity, has a width (W_p) equal to about half the height of the hook-shaped cavity or more.

3. A mold according to claim 1 or 2 in which lower portions of the pedestal chamber (P) are substantially wider than the crook chamber (C) such that space is provided for a formed hook member (12, Figs. 5a,5b) to substantially recover the shape of the cavity (1) while it is being pulled out of the cavity but before it is completely removed from the cavity.

4. A mold according to any of the foregoing claims in the form of a mold roll (80) constructed for continuous molding of a continuous sheet or strip.

5. The mold of any of the foregoing claims wherein the height (H) of the hook-shaped cavities is 0.025 inch or less.

6. The mold of any of the foregoing claims wherein the height (H) of the hook-shaped cavities is 0.020 inch or less.

7. The mold of any of the foregoing claims in which the pedestal chamber (P) tapers at a taper rate of at least 0.6 to 1 up to at least the half height (H/2) of the hook- shaped cavity.

8. The mold of any of the foregoing claims in which the taper rate of the pedestal chamber (P) is at least 0.8 to 1.0.

9. The mold of any of the foregoing claims in which at least many of the hook-shaped cavities (1) have a height (H) less than about 0.015 inch.

10. The mold of claim 8 in which at least many of the hook-shaped cavities (1) have a height of less than about 0.010 inch.

11. The mold of any of the foregoing claims in which the cavity profile defines a hook having a crook portion (corresponding to crook chamber C), at least 40% of the width of the crook portion projecting laterally from the pedestal portion (corresponding to the pedestal chamber P).

12. The mold of any of the foregoing claims in which the width of the pedestal chamber (P) that corresponds to the width (W_c) of the crook chamber corresponds with a pedestal height (P_1) of at least 30% of the total pedestal height (H_p) above the base.

13. The mold of any of the foregoing claims combined, at a molding station, with an extruder (E, Fig 4 or F, Fig. 4C) in the vicinity of the mold cavities for delivering molten resin to the cavities (1).

14. The mold of any of claim 1-12 including means (82, Fig 4 or F, Fig 4D) for applying pressure to the molten resin for promoting filling of the mold cavities.

15. The mold of claim 13 or 14 in which the hook-shaped cavities are of fixed form without moving parts.

16. The mold of claim 14 in which the cavities are defined in the periphery of a rigid mold roll (80), and the means for applying pressure includes a pressure roll (82) disposed adjacent the mold roll for directing the resin into the hook-shaped cavities.

17. The mold of claim 14 in which the means for applying pressure includes a nozzle surface (480) closely fitted to said roll for confining molten resin under pressure.

18. The mold of any of the foregoing claims wherein a plurality of contiguous, face-to-face plates (250) define a hook-shaped cavity (1).

19. The mold of any of the foregoing claims wherein the mold is a mold roll (80) having a cylindrical shape defined by circular face-to-face plates (250).

20. The mold of claim 18 or 19 in which at least some adjacent plates are laminated.

21. The mold of any of the foregoing claims wherein the hook-shaped cavity (1) is of photochemically etched form.

22. The mold of any of the claims 17-21 in which the plates (250) comprise a beryllium copper alloy and

the cavity (1) has a smooth surface produced by photochemical etching.

23. The mold of any of the foregoing claims 18 to 22 wherein the crook chamber (C) of hook-shaped cavity (1) is set at an angle with respect to the plates (250 or 151).

24. The mold of claim 23 wherein the crook chamber (C) of the hook-shaped cavity is perpendicular to the plates (250 or 151).

25. The mold of any of the foregoing claims in which the mold is a mold roll (80) and wherein the hook-shaped cavities (1) are arranged in a helical pattern about the mold roll.

26. The mold of any of the foregoing claims 1-24 in which the mold is a mold roll (80) and wherein the hook-shaped cavities (1) are aligned in a cross-machine direction.

27. The mold of any of the foregoing claims wherein the hook-shaped cavities have displacement volumes (DV) of about 1.0×10^{-6} inch^3 or less.

28. The mold of any of the foregoing claims wherein the hook-shaped cavities have displacement volumes (DV) of about 0.5×10^{-6} inch^3 or less.

29. A molded hook fastener member (12) of a hook and loop touch fastener formed by the process of delivering a moldable, heated material to a mold according to any of the foregoing claims.

30. The molded hook fastener member of claim 29 constructed to be capable of engaging low-lying loops of knitted material, or fibers of non-woven material, or the like, of a mating component.

31. The molded hook fastener member of claim 29 or 30 in which the pedestal chamber (P) of the cavity (1) in which the member is formed has a leading edge (217) and a trailing edge (218) that slope inwardly toward each other at similar angles to the mold surface to define a truncated, broad-based pyramid when viewed in side profile, the pedestal chamber base width (B_w) measured at the mold surface being greater than about the height (H) of the mold cavity, the width (W_p) of the pedestal chamber at the half height of the mold cavity being equal to about one-half the height (H) of the hook-shaped cavity.

32. The molded hook fastener member of any of the foregoing claims 29, 30 or 31 formed by extruding molten plastic resin and applying the molten resin to the mold.

33. The molded hook fastener member of any of the claims 29-32 formed on a mold roll (80), wherein moldable material is pressed into the hook-shaped cavities (1) by a pressure roll (82) disposed adjacent to the mold roll.

34. The molded hook fastener member of any of the claims 29-32 formed in a mold cavity (1) defined by mold parts that do not move with respect to one another and the moldable material is forced into cavity (1) directly by the pressure of an extruder surface (480) .

35. The molded hook fastener member of any of the claims 29-34 wherein the mold cavity (1) is defined by

mold parts that do not move with respect to one another and the fastener member is pulled from the mold without opening the cavity.

36. The molded hook fastener member of any of the claims 29-35, molded in a single hook cavity (1) comprising aligned cut-outs in at least three adjacent plates (250 or 151).

37. The molded hook fastener member of claim 36 molded in a cavity (1) defined by photochemically milled plates.

38. For a touch fastener, a molded hook member (12) integrally formed with a sheet-form base (10) in a mold having no moving parts, the molded hook member being capable of engaging low-lying loops of knitted material, or fibers of non-woven material and the like of a mating fabric, and the molded hook member comprising:

a broad-based, tapered pedestal (13) integrally formed with and extending upwardly from the base, and a tapered crook portion (14) integrally formed with and arching along a curved axis directly from the top of the pedestal to a tip (16) that engages said mating fabric;

in side profile, the pedestal having upwardly extending leading and trailing edges (17) and (18), respectively, that slope inwardly toward each other at similar angles to the vertical to define a truncated, broad-based pyramid with a pedestal base width (B_w) measured at the base, wherein projections of the leading and trailing edges intersect in the vicinity of the top of the hook, and at least 40 percent of the crook portion projects laterally from the pedestal.

39. The molded hook member of claim 38 wherein projections of the leading edge (17) and the trailing edge (18) intersect at an angle (α) greater than about 40 degrees.

40. The molded hook member of claim 38 wherein the projections of the leading edge (17) and the trailing edge (18) intersect at an angle (α) greater than about 50 degrees.

41. The molded hook member of claim 38 wherein the taper of the pedestal (13) is at least four times as large as the taper of the crook portion (14).

42. The molded hook member of claim 38 having a height (H) less than about 0.020 inch, a thickness (t) of about 0.006 inch or less and being disposed on the sheet-form base at a density of at least 1200 molded hook members per square inch.

43. For a fastener, a molded hook member having a tip portion capable of being formed in a cavity of a mold having no moving mold parts, and capable of engaging low-lying loops of knitted material, fibers of non-woven material, and the like of a mating fabric, the molded hook member comprising:

a tapered pedestal integrally formed with and extending upwardly from the base and a tapered crook portion integrally formed with and arching along a curved axis and extending in a crook direction directly from the top of the pedestal to a tip that engages the mating fabric;

the profile of the molded hook member having a height less than about 0.020 inch from its base, a

pedestal base width of less than about 0.020 inch, not counting the fillets,

the body of the hook member tapering continuously from the base to its distal tip, the taper of the pedestal being at least 50 degrees, the hook member thereby being shaped so that the cavity in which the hook member is formed provides a space for substantially immediate release for the tip portion of the hook member as it is withdrawn from the mold to enable said crook portion to return substantially to its molded shape after it commences dislodging from the mold but before it is completely removed from the mold.

44. The molded hook member of claims 38 or 43 wherein the displacement volume of the crook portion (14) is less than about 0.5×10^{-6} cubic inches.

45. The molded hook member of claim 43 wherein the tip (16) is curved down generally in the direction of the base (10).

46. The molded hook member of claim 45 in which the pedestal (13) is 0.006 inch thick or less, arranged with other molded hook members with a lineal density of 20 or more members per inch in the crook direction.

47. The molded hook member of claim 46 in which the hook members are arranged with a lineal density of 60 or more members per inch, perpendicular to the crook direction.

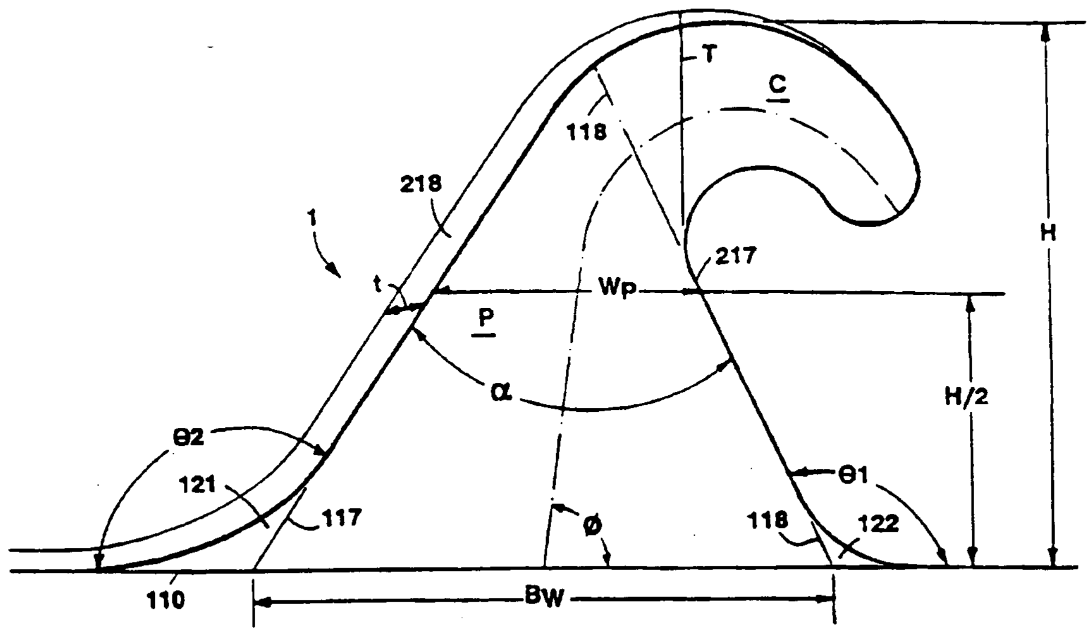
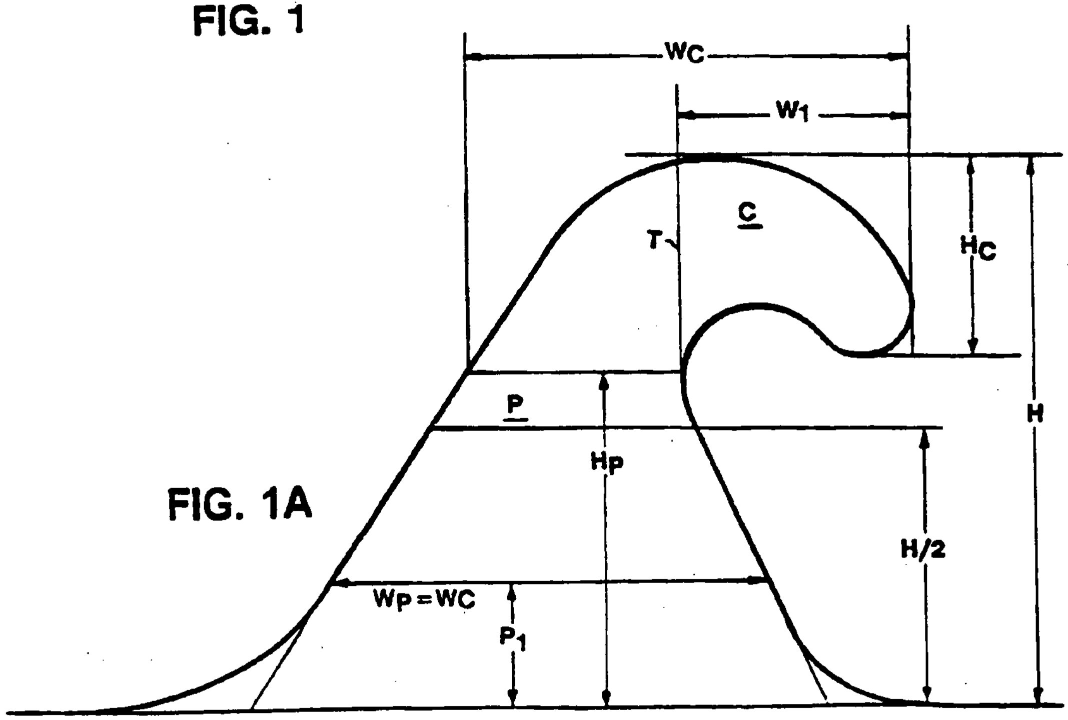

T
C
118
218
1
217
t
Wp
P
α
H
H/2
θ2
121
117
θ1
ø
118
122
110
Bw

FIG. 1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W1
C
T
Hc
P
Hp
H
H/2
Wp = Wc
P1

FIG. 1A

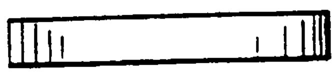

FIG. 2C

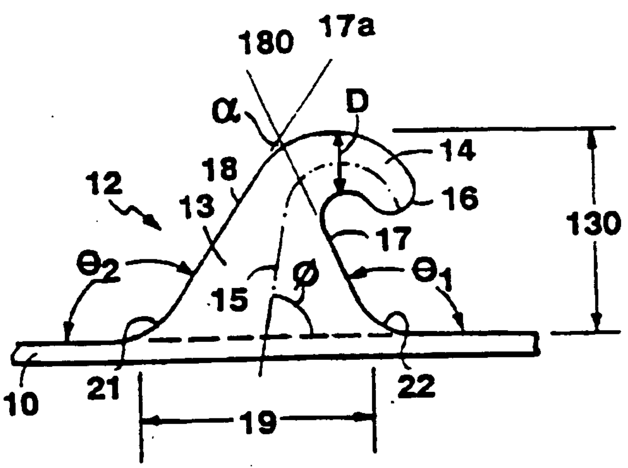

FIG. 2A

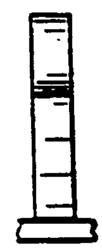

FIG. 2B

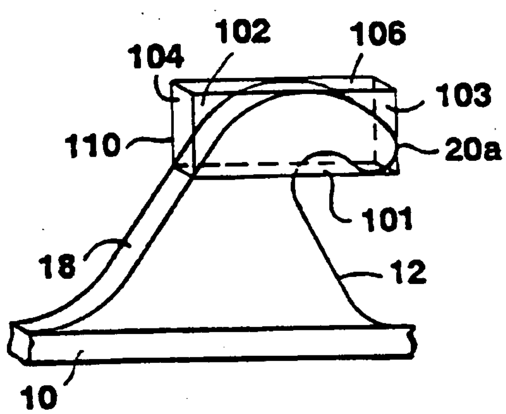

FIG. 2D

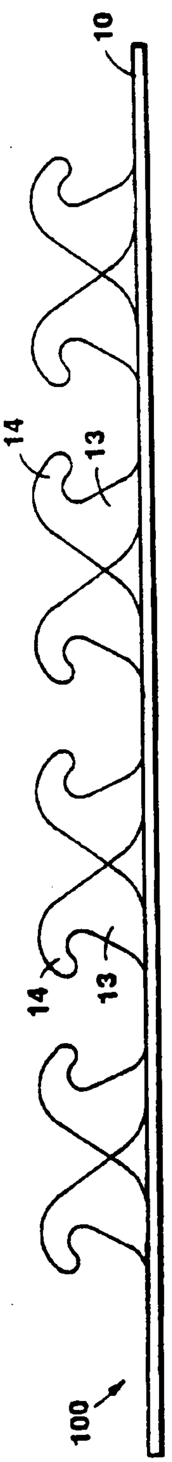

FIG. 2

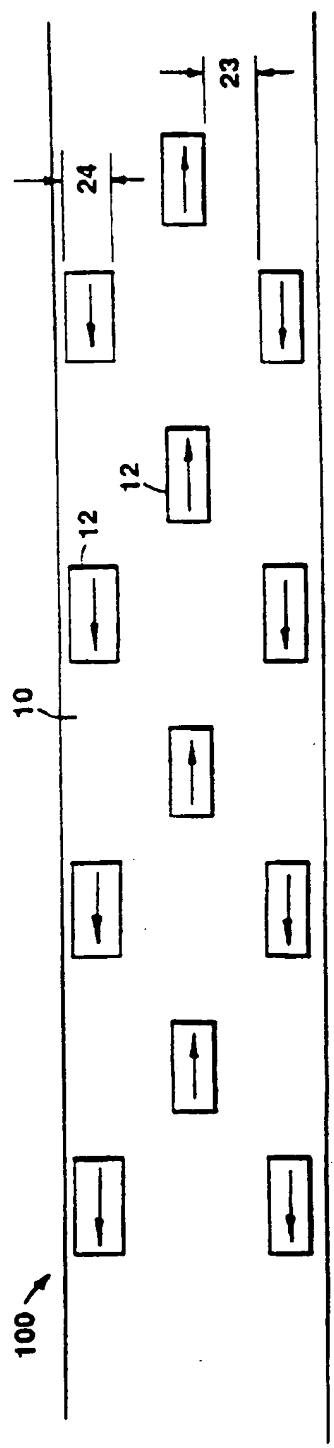

FIG. 3

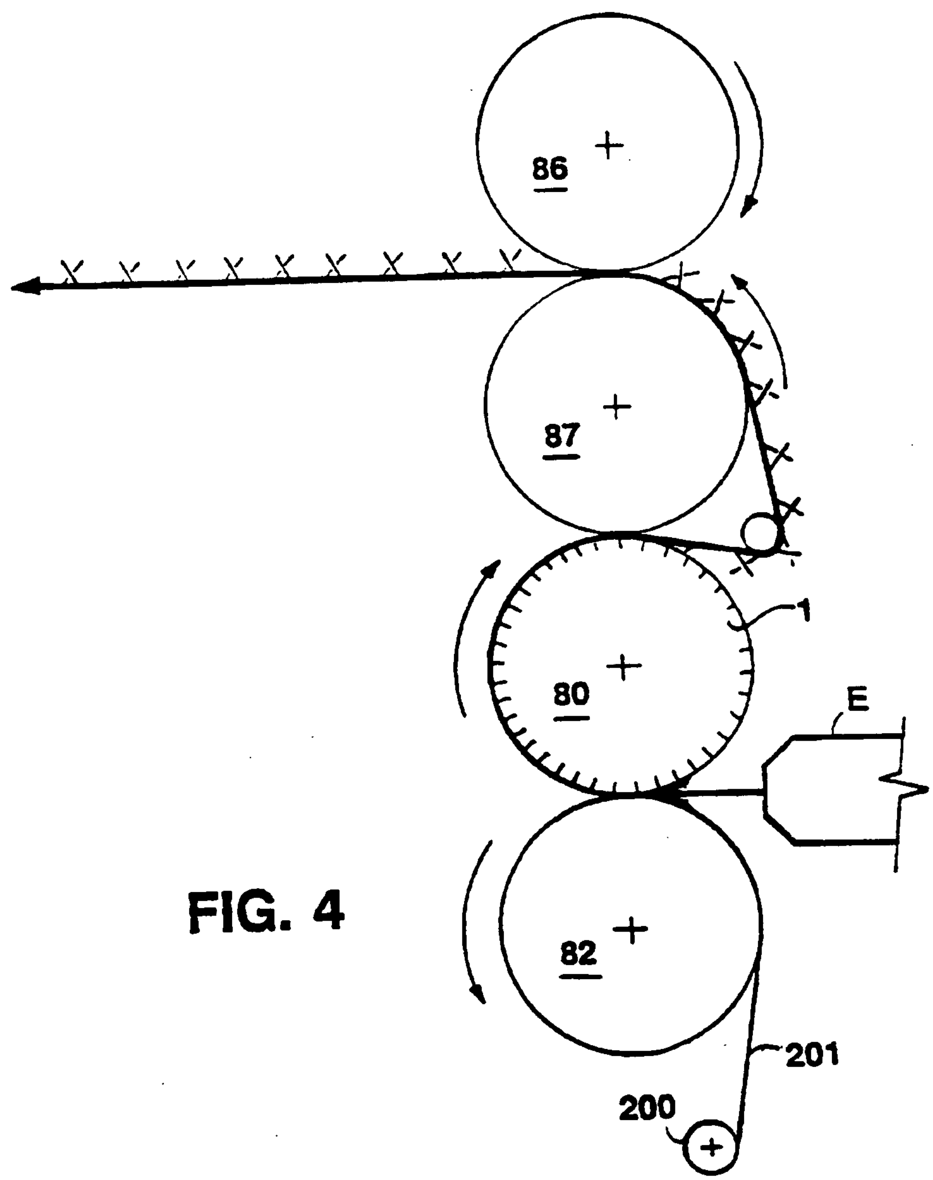

FIG. 4

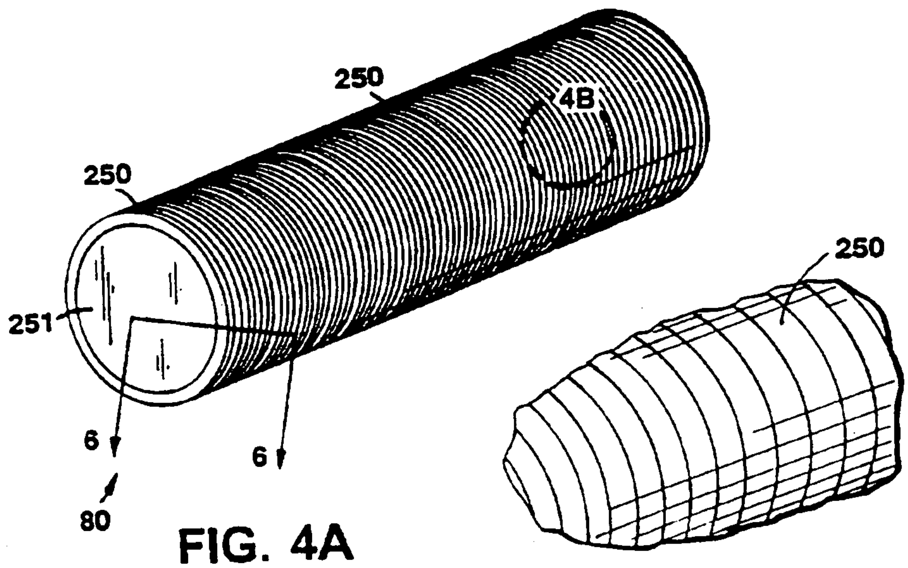

FIG. 4A

FIG. 4B

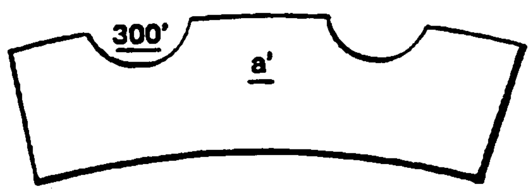

FIG. 8A

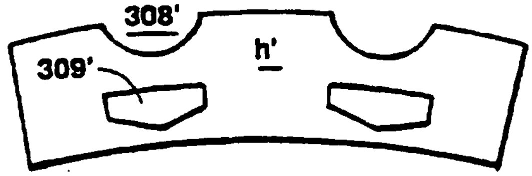

FIG. 8B

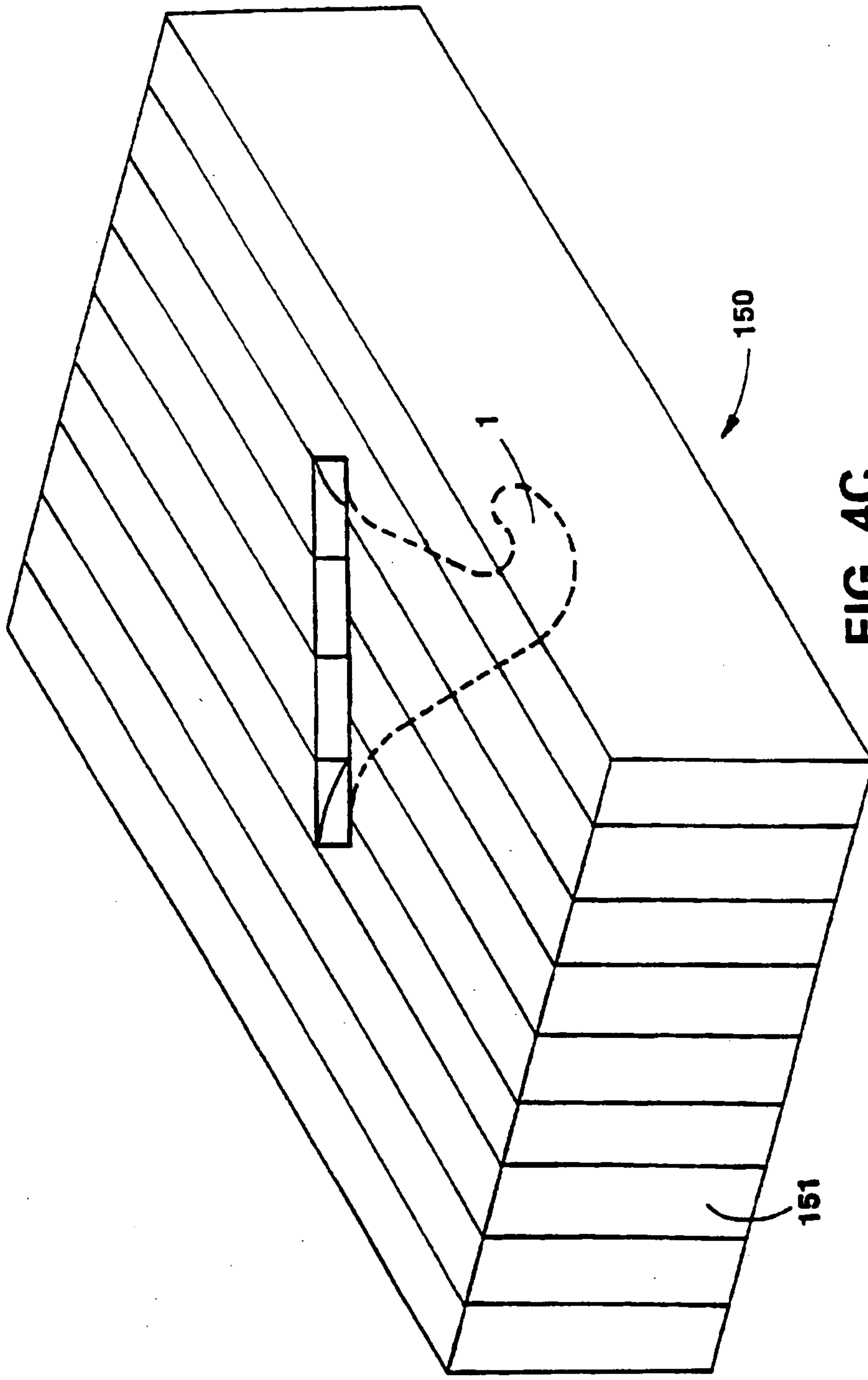

FIG. 4C

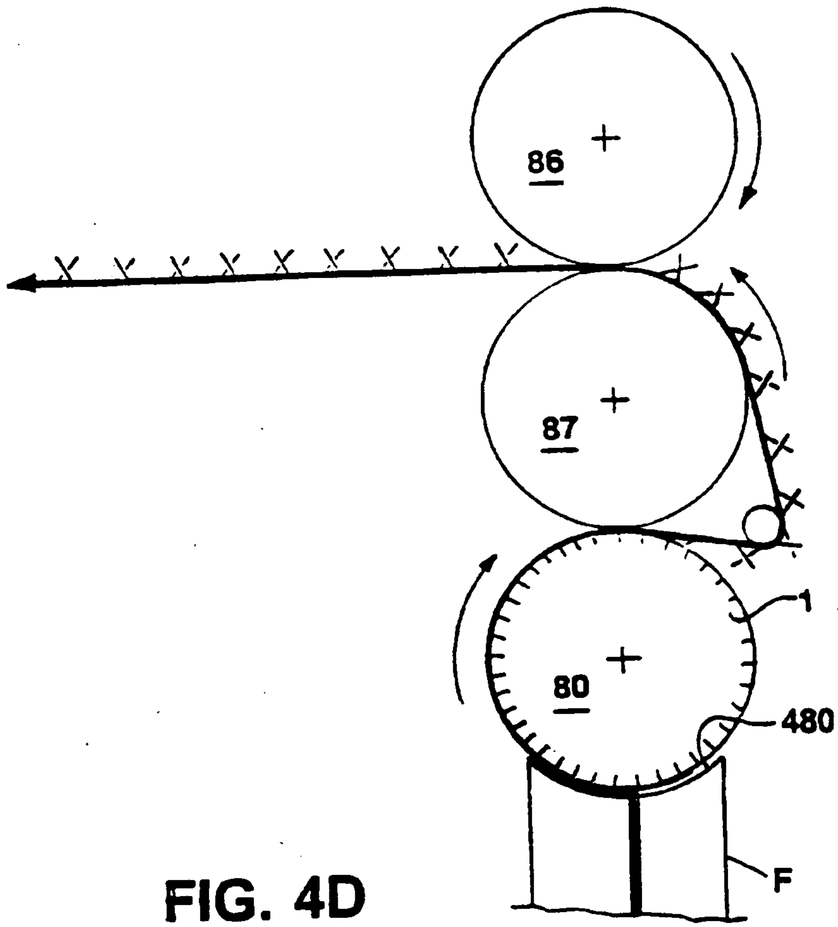

FIG. 4D

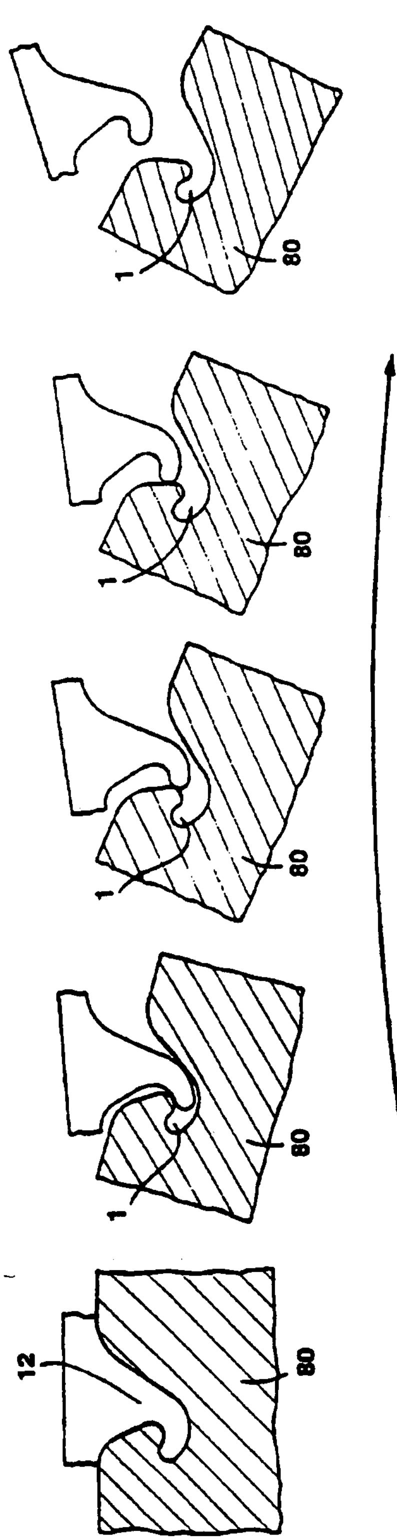

FIG. 5A

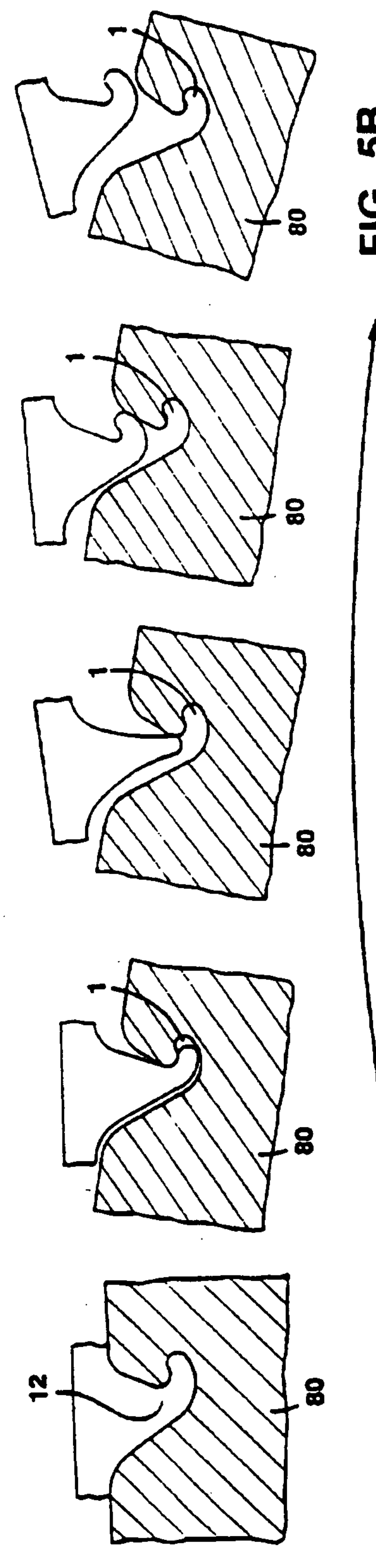

FIG. 5B

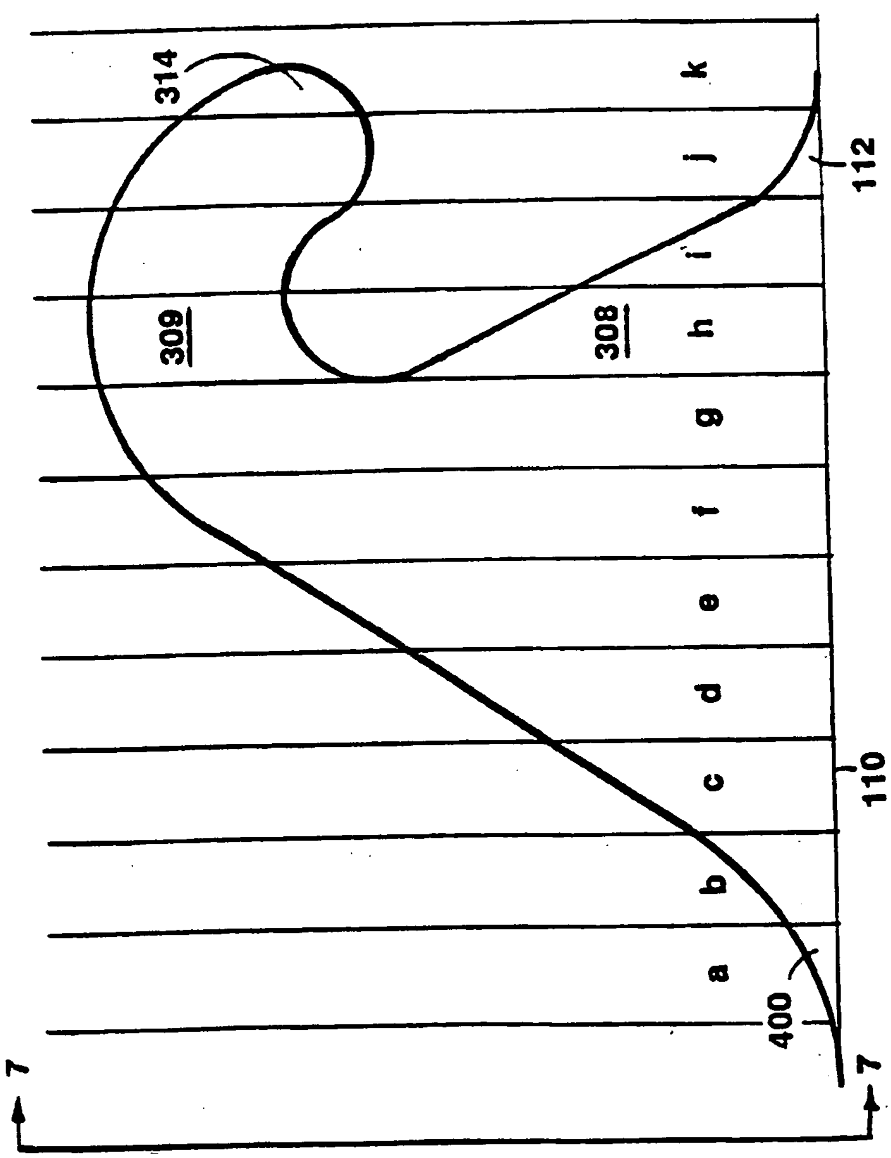

FIG. 6

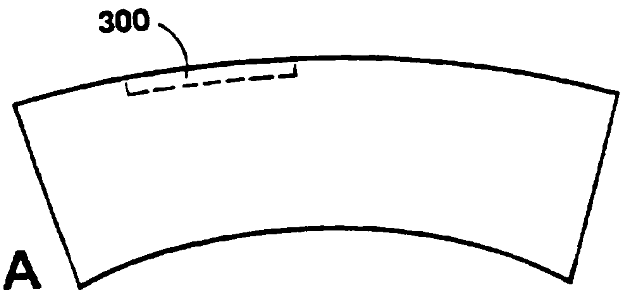

FIG. 7A

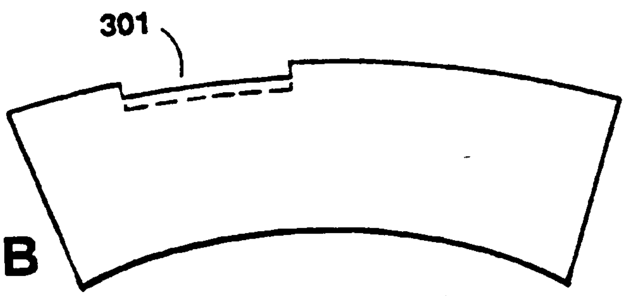

FIG. 7B

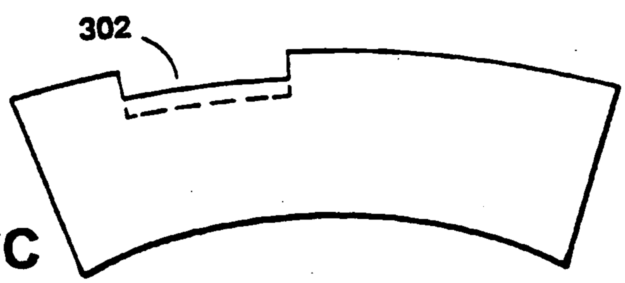

FIG. 7C

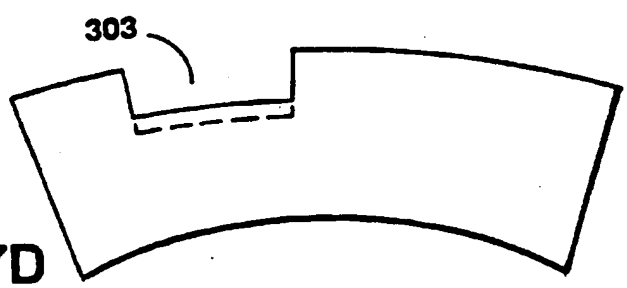

FIG. 7D

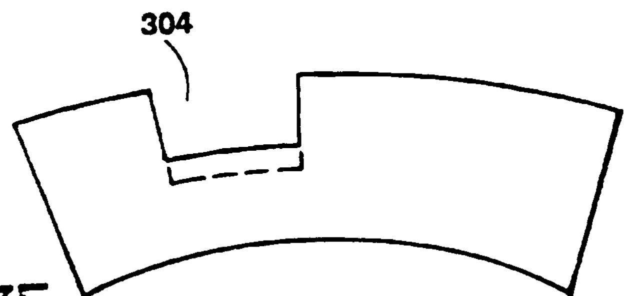

FIG. 7E

FIG. 7F

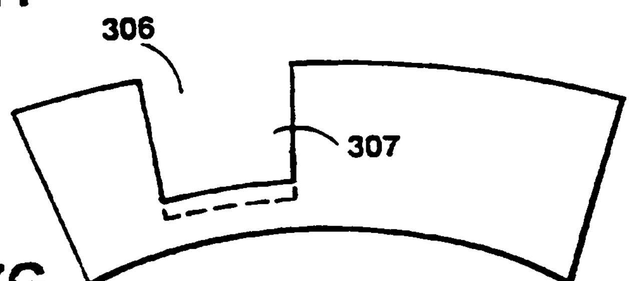

FIG. 7G

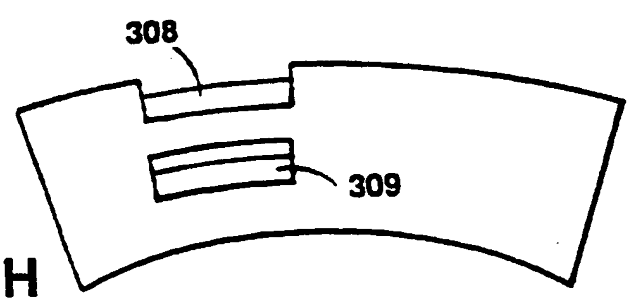

FIG. 7H

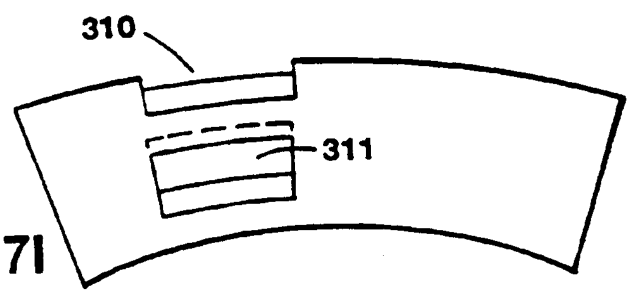

FIG. 7I

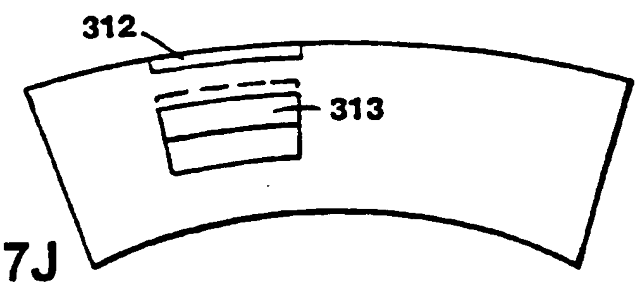

FIG. 7J

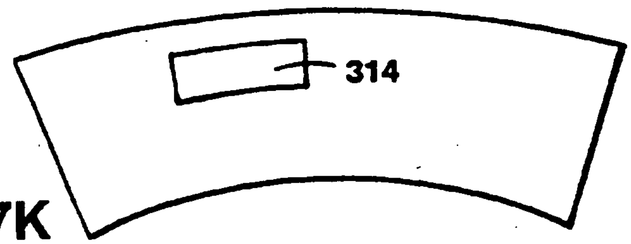

FIG. 7K

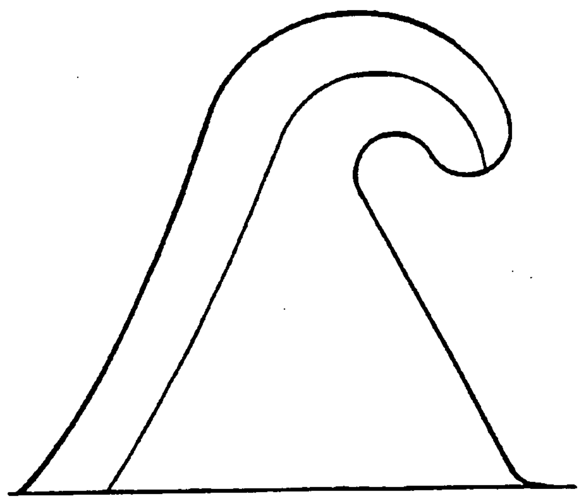

FIG. 9A

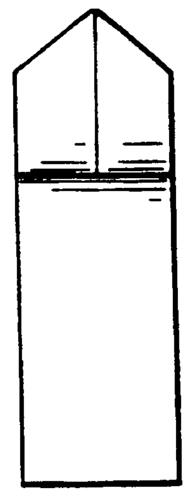

FIG. 9B

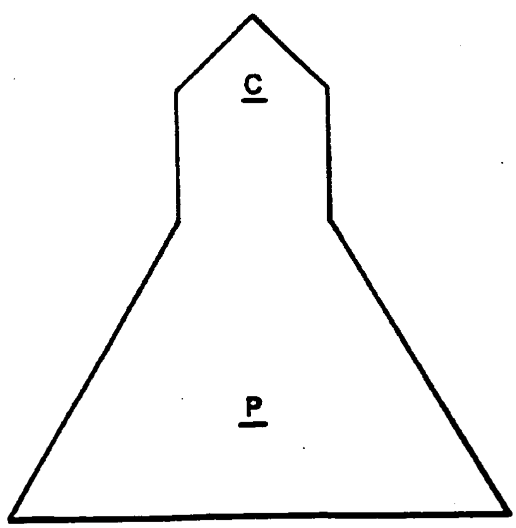

FIG. 12

FIG. 10C

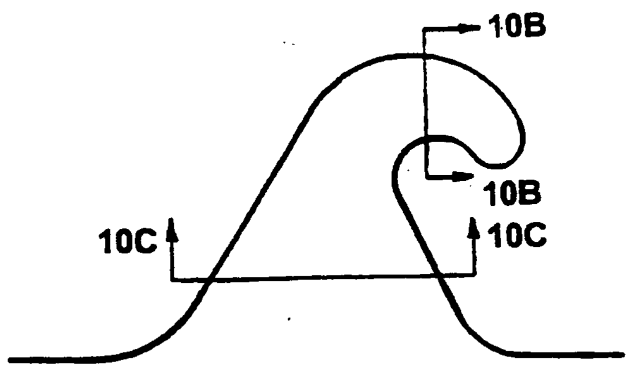

FIG. 10A

FIG. 10B

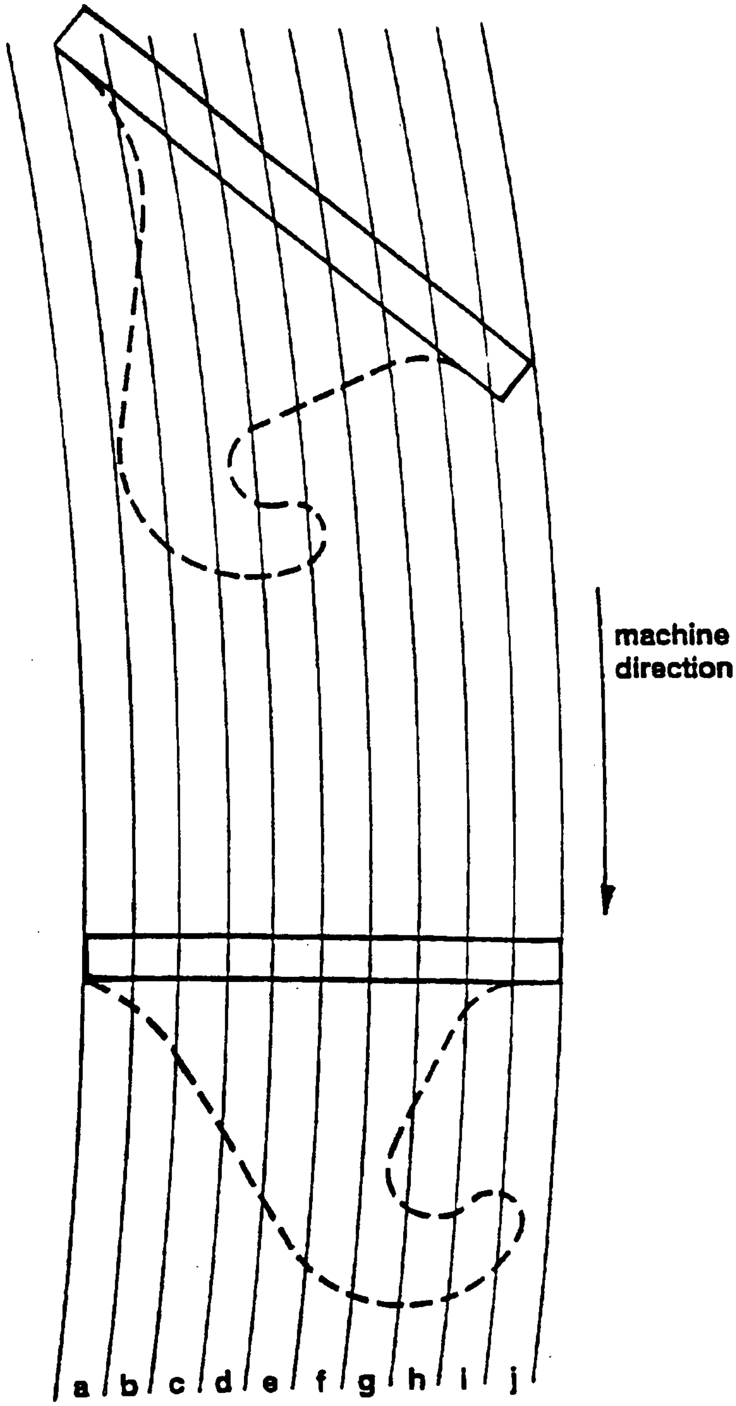

FIG. 11A

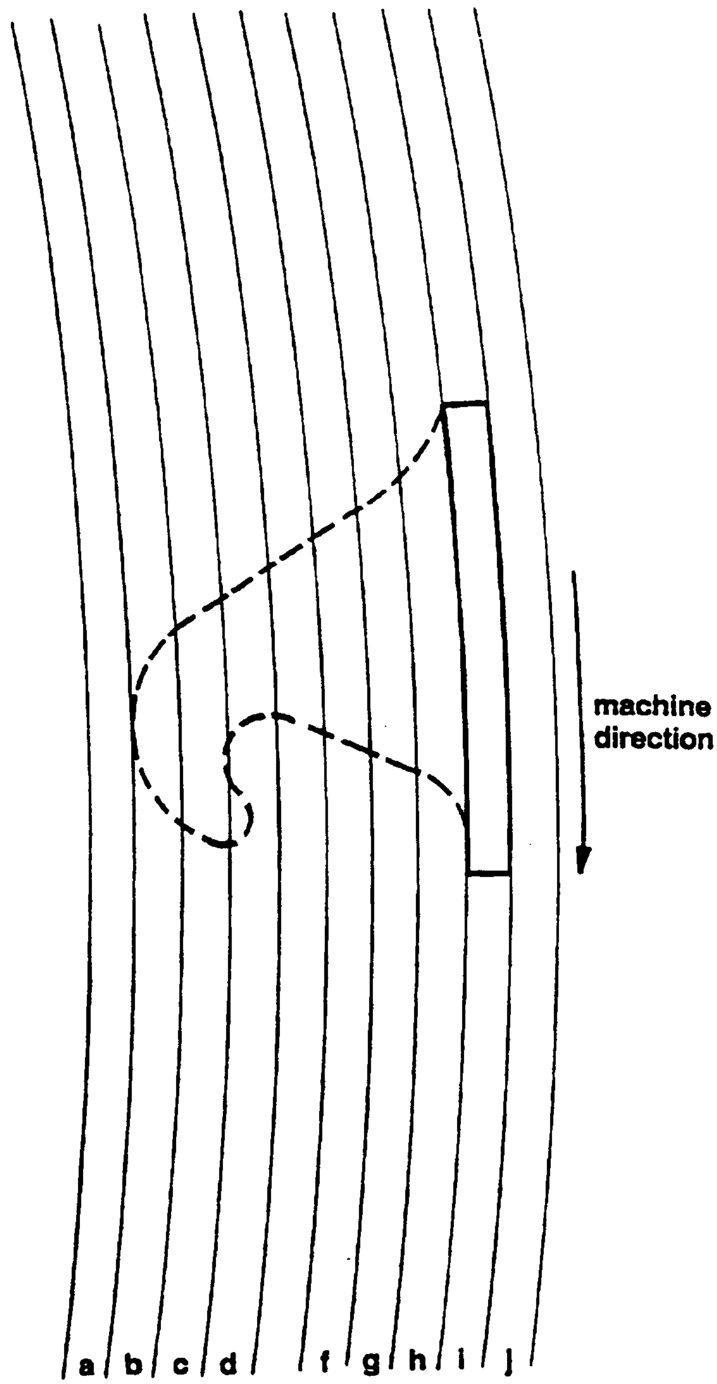

FIG. 11B

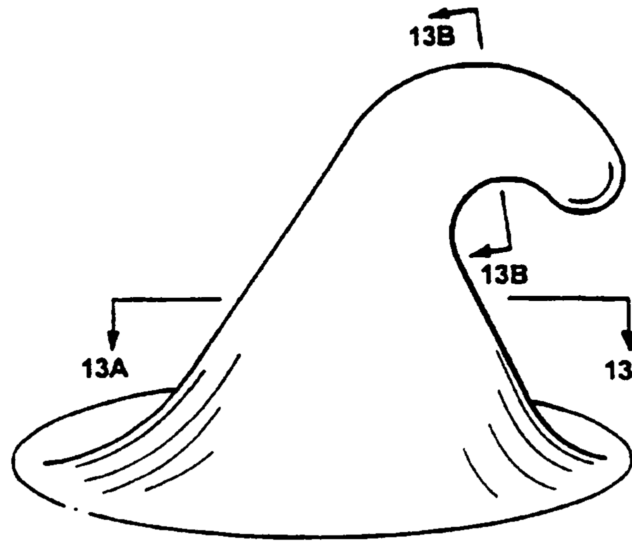

FIG. 13

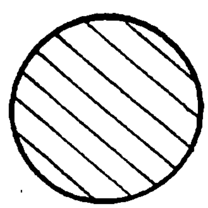

FIG. 13A

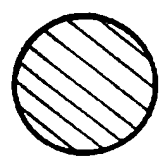

FIG. 13B

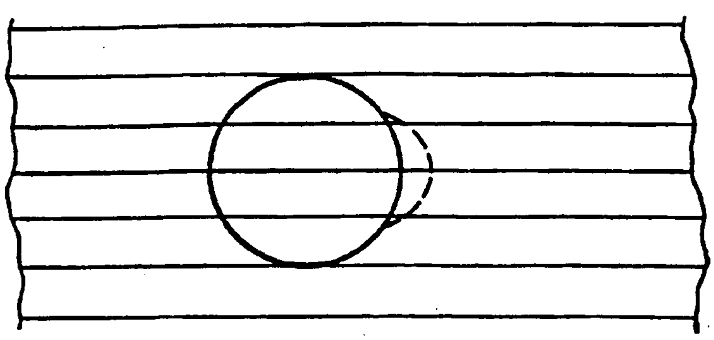

FIG. 14

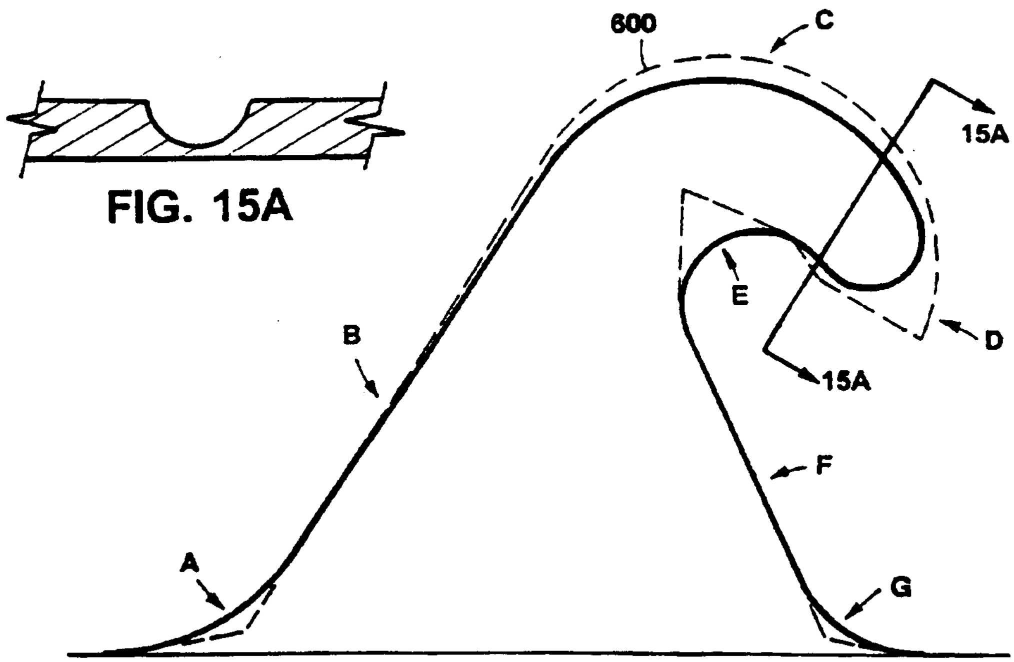

FIG. 15A

FIG. 15

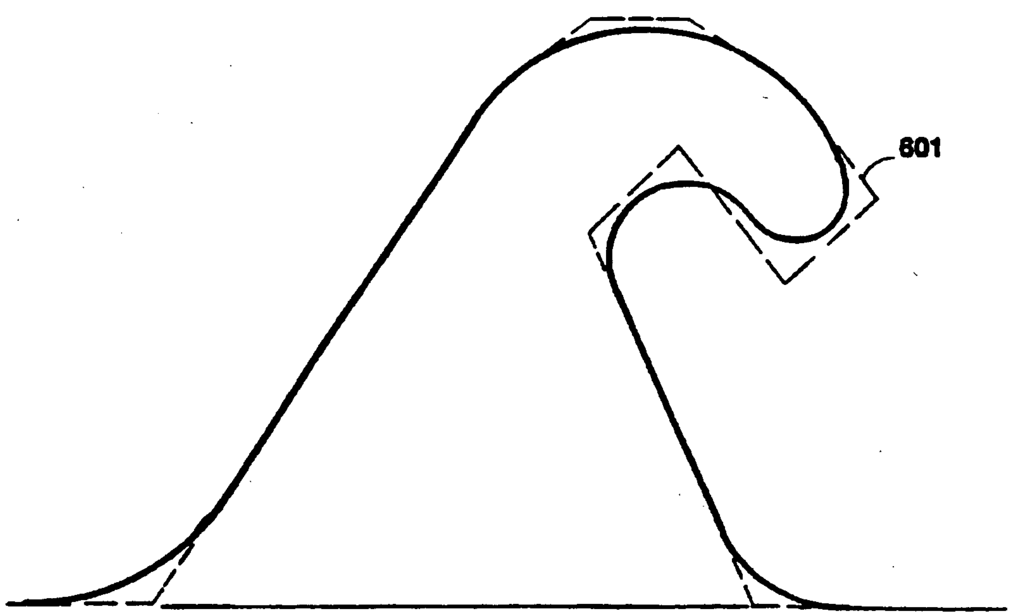

FIG. 16

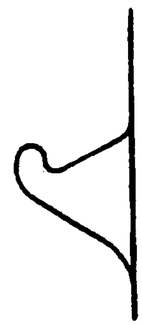

FIG. 17C

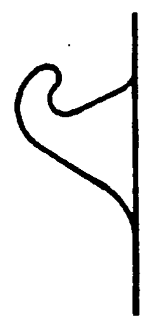

FIG. 17B

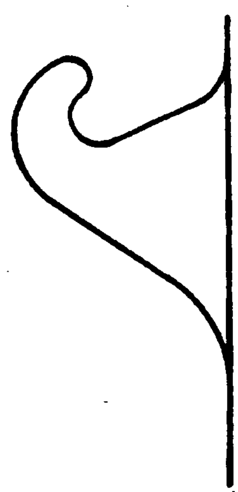

FIG. 17A

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/09956

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A44B 18/00; D01D 5/20
US CL : 24/452; 264/167, 219; 425/325
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 24/452, 450, 442; 264/167, 219; 425/325, 327, 363, 814

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,P	US 5,538,674 A (NISPER ET AL.) 23 July 1996 (23.07.96), entire document	1-3
Y	US 5,162,074 A (HILLS) 10 November 1992 (10.11.92), entire document	1-3
Y,P	US 5,604,963 A (AKENO) 25 February 1997 (25.02.97), entire document	38-47
Y	US 5,315,740 A (PROVOST) 31 May 1994 (31.05.94), entire document	38-47

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 SEPTEMBER 1997	07 OCT 1997

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	JAN SILBAUGH
Facsimile No. (703) 305-3230	Telephone No. (703) 308-3829

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/09956

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 4-37
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet(1))(July 1992)*